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Effects of posture and spinal anaesthesia on lung functions

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EFFECTS OF POSTURE AND SPINAL ANAESTHESIA ON LUNG FUNCTIONS

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A Research Report submitted to the Faculty of Medicine, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the Degree of Master of Science in Physiotherapy.

Johannesburg 1994

ABSTRACT

Post-operative alterations of respiratory function following general anaesthesia is frequent and remains an important cause of morbidity and mortality. Lung function tests are usually performed in the upright position to assess whether a patient is fit for surgery.

The objectives of this study were to determine how lung functions are affected by a change in posture and / or after the induction of spinal anaesthesia.

Twenty patients undergoing transurethral surgery under spinal anaesthesia from the urology ward, Johannesburg hospital were included in the study. Lung function tests were conducted pre-operatively, on the day of the operation and then again post-operatively. The parameters used were forced vital capacity (FVC), forced expiratory volume in one second (FEV1), forced expiratory flow (FEF) and peak expiratory flow (PEF).

The results of the lung function tests showed significant differences ($p < 0,05$) between the sitting and lying positions. The effects of the spinal anaesthesia on lung functions were minimal. Results also showed that even though the patients were supine for at least 24 hours, lung functions returned to almost pre-operative levels, post-operatively.

DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Science in Physiotherapy by coursework, to the University of the Witwatersrand, Johannesburg. It has not been submitted before to any other University.

K Laubscher

KAREN FORSYTH LAUBSCHER

THIS the 7th day of JUNE 1994

F.V.C. = maximum volume of gas the patient exhales as forcefully and quickly as possible. F.V.C. is measured in litres.

F.E.V. = maximum volume of gas that the patient can exhale during the first second during the F.V.C. manoeuvre. Normally 80% of F.V.C.

F.E.V./F.V.C.% = percentage of the measured forced Vital Capacity that a given F.E.V. represents.

P.E.F. = maximum flow rate at which a patient can exhale during forced expiration measured in l/sec or l/min.

F.E.F. (25-75%) = a related measurement of F.E.V. It represents the average flow rate measured over the middle half of the expiration.

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CONTENTS

	Page
Abstract	ii
Declaration	iii
Acknowledgement	iv
Table of Contents	v
List of Tables	vi
List of Figures	vii
Abbreviations	viii
Chapter 1 - Introduction	1
Chapter 2 - Literature Review	6
2.1 Post-operative complications	6
2.2 Anaesthesia - general vs spinal	8
2.3 Spinal anaesthesia	13
2.4 Basic pulmonary function measurement	19
2.5 Lung functions and age	24
2.6 Lung functions and habits	25
2.7 Lung functions and posture	27
2.8 Anatomy	31
Chapter 3 - Methodology	33
3.1 Patient selection	34
3.2 Equipment used	35
3.3 Method	36
3.4 Spinal anaesthesia	39
3.5 The operation	40
3.6 Statistical analysis	40
Chapter 4 - Results	43
Chapter 5 - Discussion	63
Conclusions	71
Limitations	72
List of references	
Appendix	

LIST OF TABLES **PAGE**

4.1 Demographic Data of Patients 44

4.2 FVC Effects of the Day of Measurement 47

4.3 FVC Effects of Posture and the Spinal Anaesthetic 48

4.4 FVC Effects of Different Postures and Time of Readings 50

4.5 FEV1 Effects of the Day of Measurement 51

4.6 FEV1 Effects of Posture and the Spinal Anaesthetic 52

4.7 FEV1 Effects of Different Postures and Time of Readings 54

4.8 FEF Effects of Posture and the Spinal Anaesthetic 55

4.9 FEF Effects of Posture and the Spinal Anaesthetic 56

4.10 FEF Effects of Different Postures and Time of Readings 58

4.11 PEF Effects of the Day of Measurement 59

4.12 PEF Effects of Posture and the Spinal Anaesthetic 60

4.13 PEF Effects of Different Postures and Time of Readings 62

LIST OF FIGURES **PAGE**

2.1 Distal Extent of the subarachnoid space 19

2.2 Flow Volume Curve 23

2.3 The Anatomy of the Pelvis 31

4.1 FVC Effects of the Day of Measurement 47

4.2 FVC Effects of the Posture and the Spinal Anaesthetic 48

4.3 FVC Effects of Different Postures and Time of Readings 49

4.4 FEV1 Effects of the Day of Measurement 51

4.5 FEV1 Effects of Posture and the Spinal Anaesthetic 52

4.6 FEV1 Effects of Different Postures and Time of Readings 53

4.7 FEF Effects of the Day of Measurement 55

4.8 FEF Effects of Posture and the Spinal Anaesthetic 56

4.9 FEF Effects of Different Postures and Time of Reading 57

4.10 PEF Effects of the Day of Measurement 59

4.11 PEF Effects of Posture and the Spinal Anaesthetic 60

4.12 PEF Effects of Different Postures and Time of Readings 61

ABBREVIATIONS

FVC - Forced Vital Capacity = maximum volume of gas the patient exhales as forcefully and quickly as possible. FVC is measured in litres.

FEV1 - Forced Expiratory Volume = maximum volume of gas that the patient can exhale during the first second during the FVC manoeuvre. Normally 80% FVC

FEV/FVC% - Forced Expired Volume / Forced Vital Capacity = percentage of the measured forced Vital Capacity that a given FEV represents.

PEF - Peak Expiratory Flow = maximum for rate at which a patient can exhale during forced expiration measured in 1/sec or 1/min.

FEF (25-75%) - Forced Expiratory Flow = a related measurement of FEV. It represents the average flow rate measured over the middle half of the expiration.

CHAPTER ONE

INTRODUCTION

Post operative alteration of respiratory function following general anaesthesia is frequent and remains an important cause of morbidity and mortality [1].

At present there is minimal routine physiotherapy intervention in the Urology ward at the Johannesburg Hospital. The Physiotherapy Department at the Johannesburg Hospital took a decision that the post spinal anaesthesia patient in the urology ward was at low risk for pulmonary complications, particularly in the case of those Urological operations done transurethrally (thus no exterior incision). This decision was taken for a number of reasons:

a) The apparent lack of necessity to treat these patients routinely unless there is pre-existing pulmonary disease;
b) The apparent lack of the deleterious effects on lung functions as there is minimal post-operative pain and therefore little effect on the ability to cough effectively and patient mobility.
c) Lack of staff in the physiotherapy department and therefore a need to prioritise treatment;

The medical and nursing staff, however, frequently request that these patients be treated by physiotherapists routinely as they feel the patients would benefit from physiotherapy, regardless of the lack of symptoms,

out of concern that the majority of this group of patients is elderly and also obese.

I decided to conduct this study to investigate the actual pulmonary dysfunction following spinal anaesthesia for urological surgery to facilitate a decision based on facts, keeping in mind that the majority of the patients are elderly and obese.

Pulmonary atelectasis following abdominal surgery was first described in 1910 [2]. Functional residual capacity (FRC) has been identified as the most important of all the lung volumes [1] and a post operative decrease in the FRC associated with atelectasis remains today the single most important abnormality of respiratory mechanics. Unfortunately the FRC can only be measured using dilution or washout of an inert gas or whole body plesthysmography. As these tests cannot be done in the wards, this value is seldom used to assess patients for fitness for surgery. Therefore, as is routine procedure, lung function tests were used for the purpose of this study, measured with a Schiller-Sprovitt SP-200 spirometer.

Changes in lung functions during anaesthesia may be caused by:[1]

1. Increased elastic recoil of the lung;
2. Changes in the activity of inspiratory and expiratory muscles;
3. Small airway closure and subsequent gas trapping;
4. Cephalad displacement of the diaphragm;
5. Reduced transverse cross sectional area of the thorax and an increase in the thoracoabdominal blood volume.

As the lung volume decreases towards the residual volume during expiration, small airways in the dependent regions have a progressive tendency to close, due to an insufficiently negative transpulmonary pressure. The lung volume at which closure occurs is known as the closing volume.

Risk factors that anaesthetists are frequently required to consider include the following:

a) patients with acute chest disease, pulmonary infection or atelectasis;
b) heavy smokers with subtle pathologic airways, parenchymal conditions and hyperactive airways;
c) patients with classic emphysematous and bronchitic problems;
d) patients with borderline congestive heart failure, obese patients, patients with chest deformities and the aged patients;
e) positioning during anaesthesia and surgery.

These above conditions would all predispose a patient to pulmonary complications during and after surgery and anaesthesia.

Some surgical positions, for example lithotomy, may decrease cardiac output, cause hypoventilation in a spontaneously breathing patient and a subsequent decrease in lung volumes. The intrinsic effect of anaesthesia causing a depression of the respiratory system will be magnified by the type and severity of pre-existing respiratory dysfunction as well as by the severity of intra-operative conditions that can worsen the respiratory function 3.

Lung function testing has been one of the accepted parameters for measuring fitness for any anaesthetic. It appears to be accepted by most authors[3] that there is an overall depression of all factors, such as perfusion, diffusion and ventilation, contributing to the oxygenation of the arterial blood during an anaesthetic. Most studies of respiratory function in conscious subjects have been undertaken with subjects in the upright (seated) position and anaesthesia and surgery is usually concerned with the supine, prone or lateral decubitus positions [4]. These differences in posture may have major effects on respiratory function which are sometimes greater than the effects of anaesthesia itself [5].

Patients undergoing transurethral surgery frequently have spinal anaesthesia. There are distinct advantages to spinal anaesthesia in that the analgesia and muscle relaxation effects are excellent. Depending upon the level of the block, respiration and generally, the cardiovascular system, is unaffected.

The majority of patients having transurethral surgery are over the age of 55 years. The main reason for surgery is an enlarged prostate.
Once a man turns 50 years of age the prostate starts enlarging as part of the natural ageing process. It is not understood why this occurs but it is thought to be related to testosterone levels. The prostate is dependent upon testosterone levels for growth.

It would seem then that spinal anaesthesia is advantageous in this group of patients because of the reduction in possible post-operative pulmonary complications in the older patient. Post spinal anaesthesia, patients are

treated for a further twenty four hour period in the horizontal position. This is to prevent a post-dural headache. With the patient in the supine position the postural effects on lung function may play a role in the post-operative pulmonary dysfunction. If results of this study show that there are significant post-operative changes it may indicate the need for post-operative physiotherapy for this group of patients.

The research question I wish to answer is - To what extent are lung functions altered by spinal anaesthesia and / or posture?

I postulate that with the low motor/sensory block with spinal anaesthesia used for transurethral surgery there should be no respiratory dysfunction from the spinal anaesthetic. If any, it will be caused by the postural constraints and also the presence of pre-existing pulmonary risk factors.

1.1 **AIM**

In order to make an informed decision as to whether or not the patients in the urology wards, following spinal anaesthesia, require routine physiotherapy, I propose to investigate the degree of pulmonary dysfunction in patients undergoing transurethral surgery. I propose to detect any changes by using spirometric recordings.

1. Recording lung functions in patients in different postures before and after the operation and;
2. Recording lung functions in patients before and after the spinal anaesthesia.

CHAPTER TWO

LITERATURE REVIEW

2.1 Post-operative complications

Dilworth[6] states that post-operative chest infection is a common complication of general surgery and that respiratory illness is a frequent cause of post-operative morbidity and mortality. Pre-existing pulmonary conditions are also significant risk factors. The factors that contribute to post-operative lung dysfunction are well documented. post-operative pain, spasm, immobility and paralysis are known to reduce lung function. Relief of pain does not completely restore function.

The inflated lung is inherently unstable [7], that is, it tends to collapse spontaneously. This tendency results from two physical characteristics of the intact lung -

- the presence of surface tension at the gas liquid interface of the alveoli;
- non homogeneity of the lung (regional differences) with regard to structure and function and due to the action of gravity.

Microthrombo-embolism impedes perfusion distribution, adding to all the other causes of ventilation/perfusion mismatching.

Low lung volumes tend to promote atelectasis and this provides a

rational basis for physiotherapy techniques designed to increase lung volumes. Low ventilation/perfusion areas in dependent lung regions, i.e. areas of relative underventilation, are predisposed to the development of progressive atelectasis [11]. Any influence (for example, surgery and anaesthesia) that enhances underventilation will increase this tendency.

Although routine chest physiotherapy is advocated widely to prevent the development of pulmonary complications, its value remains unproven. A number of prospective randomised studies over the past years have assessed the effect of routine post-operative physiotherapy on the frequency of pulmonary complications. I understand routine physiotherapy to mean that patients are treated post-operatively by physiotherapists prophylactically regardless of clinical symptoms. This can be confusing however, as some of the literature refers to routine physiotherapy as a regime of treatment.

Palmer and Sellick (1952)[8] found that routine chest physiotherapy proved to be of no benefit to patients undergoing lower abdominal surgery which concurs with the conclusions of Nichols and Howell (1970)[9]. In 1972 Lord, Hiebert and Francis[10] found that routine prophylactic physiotherapy caused an insignificant decrease in chest complications following abdominal surgery and is therefore of no value.

I feel rather than routine physiotherapy, i.e. prophylactic treatment, the patient should be assessed and treated accordingly. A

physiotherapy regime should be reserved for those patients who, on assessment, have post-operative pulmonary dysfunction or clinical symptoms.

Morran et al[11] support the clinical belief that routine prophylactic physiotherapy does decrease the frequency of post-operative chest infections but not atelectasis. They felt that routine physiotherapy prevented the progression of atelectasis to chest infections and that the previously mentioned articles did not distinguish between these two different complications.

Celli[12] states that the increase in chest complications and infections may be due to the decrease in mucus clearance and increased bacterial colonisation seen after surgery. The post-operative physiotherapy aims are to improve lung expansion, and mucous clearance by loosening secretions and by encouraging the patient to cough.

However, general prophylactic measures such as early ambulation, coughing and the judicious use of analgesics are believed to have beneficial effects and they seem always to be a part of the routine management of patients undergoing surgery [12]. Other aids include incentive spirometry (IS), intermittent positive pressure breathing (IPPB), and bronchodilator therapy. Controversy exists regarding the routine use of aids for lung expansion in the prevention of pulmonary complications after abdominal surgery [12,14,15]. A study by Jenkins et al[15], the results showed that there was no benefit in including breathing exercises and IS to a regime consisting of early mobilisation

and instruction on huffing and coughing as it was no more effective in restoring lung function and preventing chest infection after uncomplicated coronary artery bypass graft (CABG).

Other fairly common post-operative complications include:-

- deep vein thrombosis;
- wound infection (which is not relevant in this closed surgery);
- pressure sores;
- haemorrhaging.

Thrombosis of the deep veins of the lower limbs may occur in any patient immobilised for any length of time but occurs more frequently in high risk groups, e.g. elderly patients or those with a thrombotic history. It can have an insidious onset with no clinical signs of symptoms in the early stages when the main danger is of a fatal pulmonary embolus occurring.

The other complications do not play a large role in transurethral surgery.

2.2 Anaesthesia - general vs spinal

Nociceptive impulses transmitted to the hypothalamus and cerebral cortex result in different impulses sent to various endocrine organs, producing a variety of endocrine and metabolic effects.

Surgical procedures performed during general anaesthesia result in increased plasma concentrations of cortisol, aldosterone, renin, vasopressin, growth hormone, epinephrine and norepinephrine. In addition plasma glucose and lactate levels are increased at the start of surgery. Spinal anaesthesia has very little influence on the endocrine and metabolic activity. The blood glucose level only is increased during the induction of spinal anaesthesia [16].

Many clinicians consider spinal preferable to general anaesthesia for patients with pre-existing pulmonary disease and for the elderly patient whenever the surgical procedure is one for which spinal anaesthesia is appropriate. There have been few studies that have evaluated the post-operative pulmonary status comparing both types of anaesthesia. In a review of recent articles on respiratory effects of spinal anaesthesia, STEINBROOK[17] concludes that, although it is felt by many anaesthesiologists that spinal anaesthesia has no clinically important respiratory effects, it does result in consistent alterations in respiratory function. Published studies comparing the pulmonary complications observed after spinal or general anaesthesia have not established any consistent benefit to either anaesthetic technique. Steinbrook does comment that respiratory function is only slightly disturbed by spinal anaesthesia, while general anaesthesia has profound effect on the respiratory system. Most major surgery, e.g. thoracic and upper abdominal procedures are performed under general anaesthesia and this may explain the higher incidence, in some studies, of pulmonary complications. Very few details are stated with regard to the methodologies of the articles described and so it makes

it very difficult to comment on the articles. The studies that I found used a variety of measurements in their methodology so it is difficult to make any comparison within the studies.

Hedenstierna [18] et al describe their study in which the lung volumes of patients undergoing hip and knee replacement surgery were compared. Lung volumes were measured at four and eighteen hours postoperatively following either spinal or general anaesthesias. Both anaesthesias were associated with a decrease in functional residual capacity. However, the study was small, with only 8 patients in each group and no mention was made of the patients' ages. Mann and Bisset[19] compared the use of both types of anaesthesias in elderly patients having lower limb amputations. The incidence of respiratory infections during the first four post-operative weeks was not significantly different between the two groups. This was a larger study - a total of 60 patients and each group was similar in age. Approximately 50% of each group were smokers and 20% of each group had pre-existing respiratory disease.

Celli[12] also found there was no relationship between type of anaesthetic and pulmonary function. In his study forced vital capacity (FVC), forced expiratory volume$_1$ (FEV_1), forced expiratory flow (FEF) 25-75% were determined using a spirometer. All patients were undergoing elective upper and lower abdominal surgery under general or spinal anaesthesia. All patients were evaluated twenty four hours and four days after surgery with a spirometer. Celli's conclusion was that lung function is invariably affected by the surgery and not

necessarily by the type of anaesthetic. It is interesting that upper and lower abdominal surgery groups were not separated in this study, as generally the post-operative pain and incidence of pulmonary complications are greater in the former group. Pain from upper abdominal incisions inhibit the cough reflex and hence the greater incidence of pulmonary complications.

Nunn[5] states that pulmonary collapse is a normal feature of general anaesthesia. Compression atelectasis in the dependent lung area following the induction of anaesthesia has now been demonstrated by computed tomography. Such areas of collapse form rapidly, always in the dependent part of the lung and tend to disappear as rapidly. Rigg[7] states that the inflated lung is inherently unstable and therefore it tends to collapse spontaneously. The instability of the lung alveoli is a consequence of surface tension and regional differences in alveoli size. The tendency to collapse is increased by many risk factors such as chronic lung disease, smoking, obesity, post-operative pain, and any muscular skeletal disease associated with mechanical impairment of respiratory function.

It seems that studies indicate that both spinal and general anaesthesia can be administrated in the elderly and in patients with lung disease. The severity of the pulmonary involvement, age, overall physical condition, type of surgery and the quality of post-operative care and mobility, because of the individual effects they have on the pulmonary function, are often more important determinants of the outcome than is the choice of the anaesthetic.

2.3 Spinal anaesthesia

From a technical standpoint, regional anaesthesia depends on a knowledge of the anatomy and physiology of the central and peripheral nervous systems. Spinal anaesthesia relates largely to the physiology of the cerebrospinal fluid [20].

Augustus Karl Gustav Bier[21], a German surgeon in the very late 19th Century described how he cocainized the spinal cord in an attempt "to render large parts of the body insensitive to pain for surgical purposes". This attracted widespread attention and immediate usage at a number of centres and the development of the spinal anaesthetic of today.

The physiological responses to intradural blockade result from an automatic block. The effects on both the vascular system and the cardiac action are as a result of the removal of somatic pain and the associated reflex responses and from the effects of the blockade of motor fibres [22].

2.3.1 Respiratory and cardiovascular effects of spinal anaesthesia:

a) **Respiratory**

The mechanics of quiet breathing are not markedly affected by spinal anaesthesia. Inspiratory muscle function shows little impairment, even with high thoracic levels of

anaesthesia, although FRC is reduced [17]. Active respiratory efforts are decreased in proportion to the anaesthetic level.

The different muscles involved in respiration account for the different effects of spinal anaesthesia on inspiratory and expiratory muscle function. The principle muscle of inspiration is the diaphragm. Other inspiratory muscles are the external intercostal muscles and the accessory muscles (e.g. scalenes, sterno- cleidomastoids). Because the diaphragm is innervated by the cervical plexus (C3,4,5), even high thoracic levels of spinal anaesthesia do not inhibit diaphragmatic contraction. The force required by the diaphragm to displace the abdominal contents during inspiration is less due to the abdominal muscle paralysis that occurs with spinal anaesthesia [17].

The principle expiratory muscles are those of the abdominal wall. In normal subjects expiration is passive during quiet breathing. Active expiratory efforts are required for effective coughing and forced expiration. Patients with lung disease may recruit expiratory muscles for expiration because of the increased resistance to expiratory airflow and decreased elastic recoil of the lung. Theoretically these patients should be at risk during spinal anaesthesia.

However, in practice patients with chronic lung disease usually tolerate the altered lung mechanics of spinal anaesthesia quite well. Giesecke[23] et al studied eighteen geriatric patients with marked pulmonary disease during spinal anaesthesia for urological surgery. They report no change in the vital capacity (VC) in supine and lithotomy positions, while FEV 0.5 actually increased in 9% of patients. The control group studied consisted of 9 unanaesthetized healthy young subjects. There were decreases in the VC and FEV 0.5 in supine and the lithotomy position. I feel the difference in age, and general health in the control and experimental group do not allow for a conclusive result. The level of anaesthesia was not stated in the article, and I can only assume since it was for urological surgery, the level of spinal anaesthesia achieved was at a low thoracic or high lumbar level. The authors attribute the improvement of FEV 0.5 in the lithotomy position of the experimental group to the assisted return of the diaphragm from the weight of the abdominal contents during exhalation.

b) **Cardiovascular**

Spinal anaesthesia commonly causes arterial hypotension. In fact some reduction in blood pressure indicates clinically successful analgesia in most patients [24]. It does not appear that the minor changes in chest wall mechanics and

loss of the mechanical thoracic suction pump to aid venous return are sufficient to explain the usual circulatory changes observed during routine spinal anaesthesia.

A number of theories have been forwarded to explain this drop in blood pressure. These include:

- lumbar sympathectomy;
- direct circulatory effects of the local anaesthesia;
- skeletal muscle paralysis;
- concurrent respiratory insufficiency;
- adrenal insufficiency;

Mark and Steele[24] put forward the theory that the drop in blood pressure is caused primarily by preganglionic sympathetic nerve blockade. The degree of hypotension is related to the spread of local anaesthetic within the subarachnoid space and the extent of sympathetic blockade is not as easily quantified as that of the sensory analgesia. The variability of haemodynamic consequences of spinal anaesthesia may be attributed to varying and unpredictable degrees of sympathetic blockade.

2.3.2 **Drugs used for spinal anaesthesia**

Lambert[25] states that spinal anaesthesia is the anaesthetic technique with the highest rate of success although this

depends on the skill of the anaesthetist. The drug selection is important and depends on a number of factors:

- the segmental level of nerves innervating the operative site;
- the duration of the operation;
- the intensity of the motor block required.

One of the drugs most commonly used during spinal anaesthesia is bupivicaine, which is a local anaesthetic drug. It is often rendered hyperbaric by adding dextrose to increase its density. This is to ensure that the solution remains in the vicinity of the injection site, thereby providing intense anaesthesia of prolonged duration. More dense solutions (hyperbaric) gravitate to the dependent regions and less dense (hypobaric) solutions float to the least dependent areas.

Various factors influence the spread of the drugs in the arachnoid space. These relate mainly to fluid dynamics:

a) dispersion - the actual mixing of the drug;
b) displacement - the volume of the drug determines the spread in the 30 ml reservoir of cerebrospinal fluid;
c) convection - depends on the specific gravity of the drug.

Immediately after injecting, the local anaesthetic agent is taken up by neural elements particularly the posterior and lateral

aspects of the spinal cord, as well as by the spinal nerve roots. This is known as the fixation time. The drug used for the spinal anaesthesia in this research was Bupivicaine. The fixation time for Bupivicaine is approximately 15 minutes. Muscle relaxation is excellent and depending upon the level of the block, respiration and generally the cardiovascular system is unaffected.

Factors such as baricity (density), gravity (patient position) and shape of the spinal curves play a role in the distribution of local anaesthetic drugs. The curvature of the human spinal canal created when a patient is in the supine position reveals a lumbar lordosis at the L_{3-4} interspace. These curves influence the distribution of the hyperbaracic and hypobaric solutions. The distribution of isobaric solutions is unaffected by the shape of the spinal canal. Areas innervated by nerves below the L_1 dermatome may conveniently be anaesthetised by using an isobaric solution. Anaesthesia can be induced in any position and the patient then placed in the position for the operation. Because spinal nerves L_1 to S_5 pass through the cerebrospinal fluid, into which the isobaric solution is injected, anaesthesia in all of these dermatomes will result.

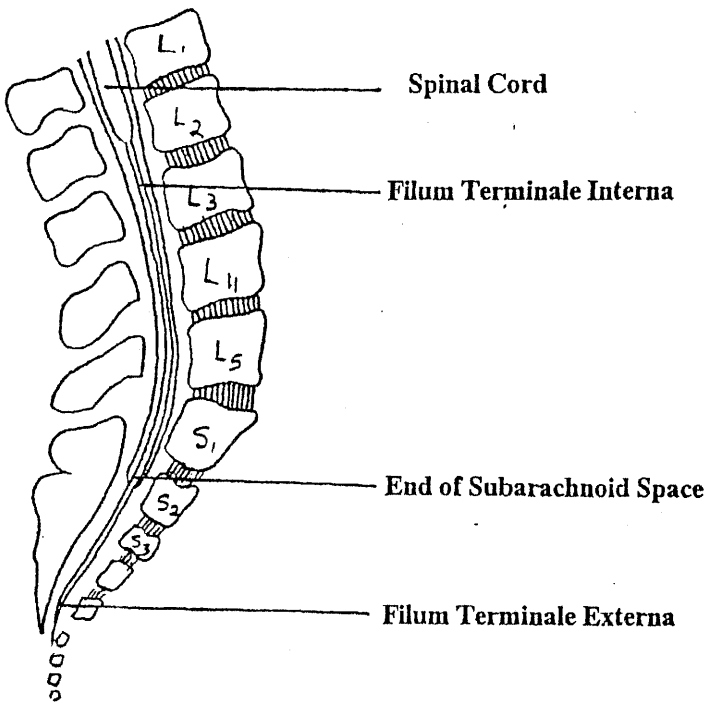


Figure 2.1 **Distal extent of the subarachnoid space**

2.4 Basic pulmonary function measurements

Pulmonary function testing provides the mechanism to evaluate the ability of the lungs to maintain ventilation and oxygenation. The clinical application of test results provides valuable information concerning the cardiopulmonary status of the patient and is valuable in helping to assess whether or not a patient is fit for surgery.

A review of the literature reveals no additional information other than that found in textbooks of basic pulmonology. This is described in the following paragraphs.

2.4.1 **Pathologic considerations** - the basic classification of pulmonary disease consists of obstructive, restrictive and combined respiratory disease:

Obstructive disease is characterised by the patients decreased ability to exhale maximally. The primary factor is the increase in airway resistance. This is caused by bronchospasm, pulmonary secretions and/or a breakdown of the structural support system of the small airways, resulting in decreased airflow during inspiration and expiration (FEV_1, and FEV/FVC%).

Restrictive disease is characterised by a loss in lung volume. The primary factor is a decrease in lung compliance. This can result from changes in the parenchyma and/or the chest wall. It occurs commonly as a result of inflammatory and fibrotic lung diseases (Normal FEV/FVC% as both are decreased).

Combined disease. There are no single parameters that can characterise combined lung disease. It is a combination of the above two.

2.4.2 Testing can be divided into conventional and supplementary testing. The lung can be divided into separate volumes which can be added together in various combinations called lung

capacities. The majority of lung volumes are recorded and measured through simple spirometry The residual volume and therefore total lung capacity and the functional residual capacity cannot be measured directly during simple spirometry. These are measured with helium distribution, nitrogen washout or body phethysmography.

In normal persons the volume of air in the lungs depends primarily on body size and build [26]. In addition, the various volumes and capacities change with the position of the body; decrease on lying down and increase on standing. This change with position is caused by two major factors:

a) a tendency for the abdominal contents to press upward against the diaphragm in the lying position;

b) an increase in the pulmonary blood volume in the lying down position which correspondingly decreases the space available for pulmonary air [26].

Pulmonary testing is commonly performed in the sitting position. Test results are reported in relationship to the normal predicted values. The predicted values are based on the patient's age, sex and height. Regardless of the position of the patient during testing the results will be compared with the predicted values in the upright sitting position.

Tests that measure airflow provide important information relating to the actual function of the lungs, the degree of impairment and often the general location (e.g. large/ small airways). Timed Forced Expiratory values (FEVt) provide valuable information. Such tests measure the ability of the patient to maximally exhale as much as possible and in the shortest possible time.

2.4.3 The significance of the results :

Vital Capacity:- Other than the anatomical build of a patient, the major factors affecting it are -

a) position of the patient during the VC measurement;
b) strength of the respiratory muscles;
c) distensibility of lungs and chest cage (pulmonary compliance).

A thin person will have a higher VC than an obese person of the same sex, age and height. A well developed athlete may well be 30-40% above normal.

Any factor that reduces the ability of the lungs to expand also reduces the VC, e.g. asthma, chronic bronchitis and emphysema. These pathologies can reduce the pulmonary compliance and therefore also the VC. For this reason VC is among the most important indicators for assessing progress of pulmonary fibrotic disease.

In left sided heart failure or any disease that causes pulmonary vascular congestion and oedema, the VC becomes reduced because excess fluid in the lungs reduces pulmonary compliance.

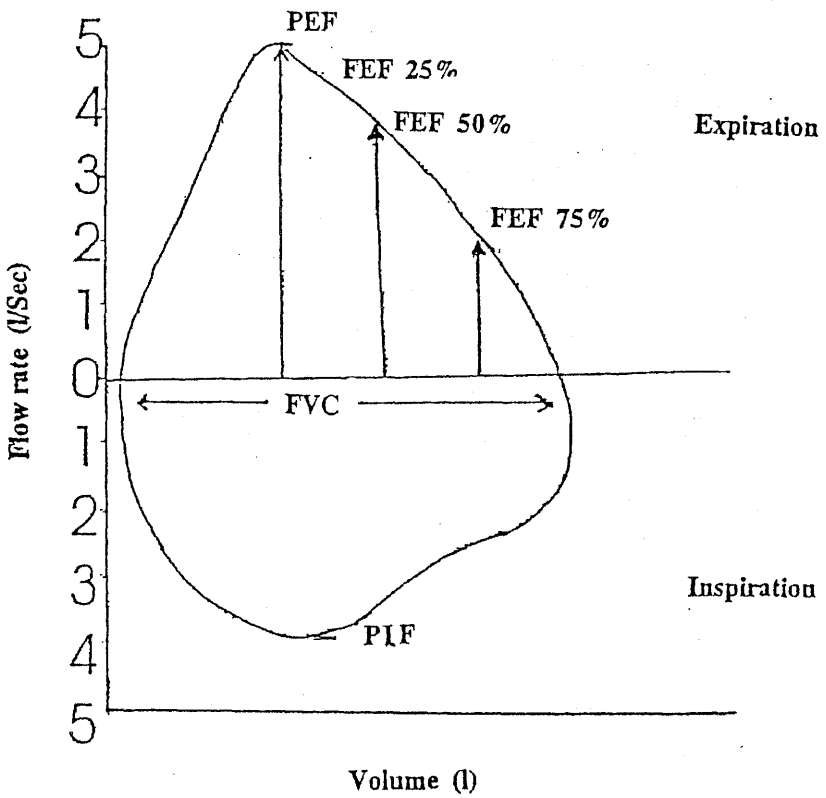


Figure 2.2 **Flow Volume Curve**

FEV (or FEF 25-75%) is reduced by an increase in airway resistance or a reduction in elastic recoil of the lung. It is remarkably independent of expiratory effort. The reason for this is the dynamic compression of the airways [27].

The flow rate is determined by the elastic recoil pressure of the lung and the resistance of the airways upstream of the collapse point. The location of the collapsed point is in the large airways, at least initially. Both the increase in airway resistance and the decrease of elastic recoil pressure can be important factors in the reduction of the FEV_1, as for example, in pulmonary emphysema.

2.5 **Lung functions and age**

The closure of small airways in dependent lung zones of normal subjects has been described by a number of authors. Airway closure is thought to occur when the net forces acting on the small airways are such as to induce their collapse [28]. Elastic forces in the pulmonary parenchyma and properties of the airways themselves are seen as opposing closure. There is a reduction of elastic recoil and loss of airway integrity in the aging lung with less opposition to airway collapse. Craig[28] feels this explains the observations of an increase in airway closure with age.

Leblanc[29] measured the closing volumes and different lung volumes in sitting and supine lying, in 80 subjects whose ages ranged from 18 to 80 years. The closing volumes increased linearly with age. In Leblanc's[29] study he found that in the erect position closing volumes exceeded expiratory reserve volume in subjects older than 65 years while in the supine position, the expiratory reserve volume is markedly reduced from the age of 44 years. It is felt that this is a valuable study due to the large sample number and well controlled methodology. This viewpoint is opposed by Hedenstierna[18], who states that regardless of the position, the FRC increases with age and moving from the upright to supine position considerably reduces the FRC. Dean[30] states that there is a reduction in FRC in those individuals who are older, and also that the supine lying position further reduces the FRC.

2.6 **Lung functions and habits**

Dean[30] states that in the supine lying position there is a reduction of the FRC and the decrease in this value is even more considerable in those patients that are older, overweight or who smoke and whose FRC tends to be close to the closing volume. Hence it is important to avoid the supine position in high risk patients. This was confirmed by Selsby and Jones[31] in their discussion on the benefits of a physiotherapist's pre-, peri- and post-operative patient care.

Smoking:

Leblanc's[29] study states that the closing volumes in light smokers tended to be slightly higher than those in non smokers, and there is a significant difference when comparing heavy smokers and non-smokers. The closing volumes may become higher than FRC contributing to the closure of airways and atelectasis.

Aldrete et al[32] undertook a study in patients undergoing a variety of surgical procedures, comparing the changes produced by spinal anaesthesia on FEV_1, and flow rates in patients with varied smoking histories. The sample size of this study was 25 patients between the ages of 24 and 64 years. Although this was a relatively small study it does show that cigarette smoking may be considered as a definite factor predisposing to respiratory complications. A correlation of these results with the level of sensory blockade was made. All patients were premedicated at least 45 minutes before the initial spirometry tests were performed.

Changes in all readings showed mild alterations (+5 to -25%) in the majority of non and light smokers, whereas moderate and heavy smokers had wider variations.

Obesity:

Catenacci[33], evaluated the clinical impression that the obese patient exhibits greater respiratory and circulatory dysfunction than the non

obese patient during spinal anaesthesia. The eight patients in this study were at least 25% and up to 86% over the ideal weight. The mean age of patients was 44 years (ranging from 21 to 66 years). All values were taken with patients in supine and these were compared with the standard predicted values (sitting position). A control group consisted of 8 non obese patients. All the patients had premedication given prior to the spinal anaesthesia. The inspiratory capacities and vital capacities were compared. There were comparable ventilatory changes in both groups of patients. The most significant change obtained was the increase in the PaO_2 after spinal anaesthesia in the obese patients as compared with the non-obese patients.

Jenkins and Moxham[34] conducted a study in 144 males awaiting coronary artery surgery. Patients were divided into three groups according to their body mass index. No patients were underweight. Lung functions as well as arterial oxygen and carbon dioxide tensions were recorded on each patient. The results showed significant differences, especially in the FRC expired reserve volume and arterial oxygen tension in the mildly obese patient.

The study concluded that obesity, even when mild, significantly impairs lung function.

2.7 **Lung function and posture**

Mechanical function of the normal respiratory system may be altered by changes in the gravitational environment due to the alteration of

the body's position. Beckett[35] states that within minutes of going from the erect to the supine position, lung volumes in a normal subject decrease. These changes in the lung volumes have been assumed to persist while the supine position is maintained and may be due to the increased flow of blood from the lower body into the chest.

The adequacy of ventilation - perfusion (V/Q) matching is an essential mechanism for gas exchange. The V/Q ratio decreases down the upright lung. Ventilation and perfusion increases independently from the top to the bottom of the lung. Dean[30] reports that perfusion is observed to increase proportionately more than ventilation down the upright lung, because of the greater effect of gravity on blood than inspired air and a greater compliance of the bottommost airways than those of the uppermost.

Studies previously done of lung mechanics before and after prolonged bedrest have not detected significant changes other than those seen immediately on lying down [35,37,38]. Beckett et al (1986)[35] reexamined the above findings. They measured FEV and FVC in patients in the supine position and demonstrated an increase in both parameters during the prolonged bedrest. The subjects remained in bed for 11-12 days. Subjects did not exercise while in bed and were limited to a daily 15 minute period of sitting. The results suggest a gradual process independent of muscular force or strength. Without change in either neuromuscular output or lung compliance there may be a shift in the configuration of the abdominal wall or the anatomical

relationship of the inspiratory muscles to the chest wall that improves their mechanical advantage without increasing their maximum tension.

An hypothesis that would support these[35] results could be that the anatomical adjustments, occurring gradually over several days after the acute decrease in lung volume on going from the upright to the supine position, would represent an opposite and approximately equal compensatory change to the initial postural change in lung volumes.

Numerous studies [5,18,29,30,35,39] have stated that there is a marked Functional residual capacity (FRC) reduction in changing positions from sitting erect to supine lying. In order to explain this phenomenon a number of theories have been proposed.

Vellody[39] states that the reduction in the FRC is accounted for by the cephalad displacement of the diaphragm. Stretching of the diaphragm in the supine position may also cause it to exert an inspiratory action on the lower rib cage, countering some or all of whatever expiratory gravitational effects which may remain while in the supine position.

Nunn[5] has shown in his study that when a patient is in the supine position the FRC is about 1 litre less than in the upright position. There is a further reduction of approximately 450 millimetres after the induction of general anaesthesia. The decrease occurs immediately after induction of the anaesthesia and is not progressive. He states

that possible causes could be the cephalad movement of the diaphragm, a decrease in the cross sectional area of the ribcage and movement of blood into and out of the thorax.

Leblanc's[29] study, which was performed on healthy individuals of different ages, also found a reduction in the FRC. When the closing volume exceeds the expiratory reserve volume, airway closure occurs. Airway closure tends to occur when an individual breathes at low volumes. Positions in which the FRC was not favoured included supine lying as this resulted in airway closure in a significantly younger patient (44 years old as opposed to 65 years) than in the erect sitting position. As this study was performed in healthy individuals, it is fair to assume that these effects could be more marked in patients with pulmonary disease and those with prolonged histories of smoking.

In an attempt to determine the influence of posture on ventilatory muscle strength and on lung function, Gounden[40] studied spirometry in three different positions. These positions included sitting erect, sitting leaning forward and in a supine lying position. He found that FVC, FEV_1, and PEF all were decreased significantly in the supine lying position. He also found that the sitting leaning forward position was superior to the other two positions in asthmatic patients. This appears to support a theory of VELLODY[39]. However, the control group consisted of 57 young healthy university students and the experimental group consisted of 14 chronic asthmatics with ages ranging from 30-55 years. The asthmatic group was studied either in

remission or just after an acute attack and were all receiving daily bronchodilator therapy. There is no mention whether the study was conducted before or after bronchodilator therapy. I feel there were too many variables in this study for it to be conclusive.

2.8 Anatomy

The prostate is a firm body, partly glandular and partly muscular, which surrounds the neck of the bladder and the beginning of the urethra.

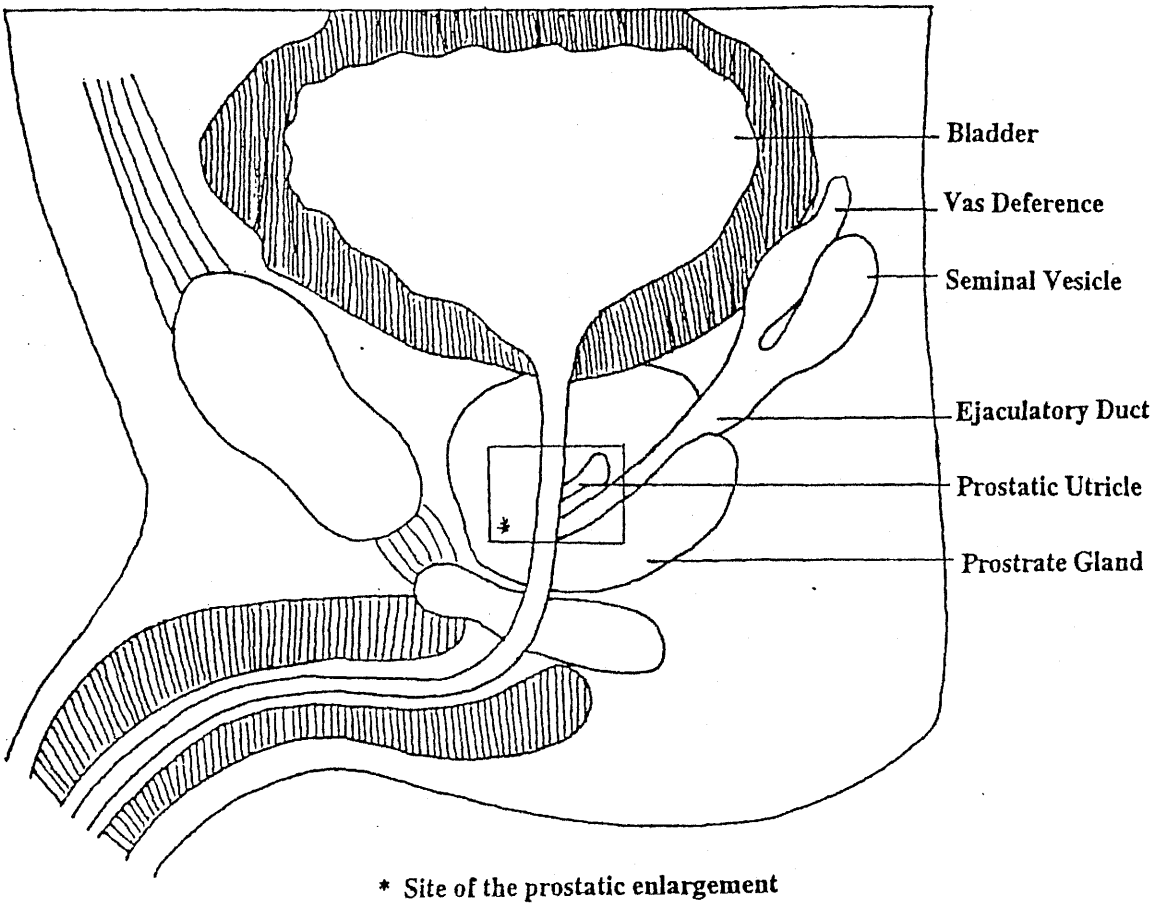


Figure 2.3: The anatomy of the pelvis

The median lobe is the portion of the prostate which lies between the ejaculatory ducts and the urethra, and it is this part of the gland which is often enlarged in elderly men. Even a small enlargement may form a valve over the internal urethra orifice, causing obstruction to the passage of urine.

The nerve supply to this region is from the ventral rami of 3rd and 4th sacral nerves superiorly and by a branch of the pudendal nerve inferiorly. Therefore a spinal anaesthetic at the $L_{2/3}$ level will give very adequate analgesia for the surgery.

CHAPTER 3

METHODOLOGY

A prospective study was performed in the Urology Ward, Johannesburg Hospital, during the months September to January 1991/1992.

Schematic Diagram of Study Structure

Patient admitted to urology ward - Johannesburg Hospital.

↓

Random Selection

↓

1. Day prior to surgery
   - patient interviewed and data sheet completed
   - patient weighed and height measured
   - lung function test explained and demonstrated
   - lung function test performed in sitting and lying positions

↓

2. Day of surgery
   - lung function tests performed before and after spinal anaesthesia

↓

3. Day following surgery
   - lung function tests performed in lying and sitting positions

3.1 **Patient selection**

Twenty Five patients undergoing transurethral resection of the prostate gland (TURP) were randomly selected. The patients were all males over the age of 65 years. The patients were randomized by the drawing of either an odd or even number from a box of numbers. All patients choosing an odd number were included in the study. Those choosing an even number were excluded from the study. All patients selected for this project were admitted for elective surgery in the Urology ward. All patients agreed to undergo the spinal anaesthesia.

The Urologists have a theatre list on Mondays, Tuesdays and Thursdays. On average 4 patients undergo T.U.R.P. surgery per week. Patients are booked for theatre as they require surgery and so the lists on each day have similar types of patients, i.e. according to age, severity of condition and health.

The exclusion criteria for this study were:

1) the patient's inability to understand the examiner's instructions and therefore their inability to comply with lung function testing;

2) if the patient needed general anaesthesia according to the anaesthetist;

3) if the patient refused spinal anaesthesia;

4) if the patient needed further investigations prior to surgery and therefore the operation was cancelled/postponed;

5) if the spinal anaesthesia failed and needed to be converted to a general anaesthesia;

6) if the patient needed any drugs that would affect the study.

The subjects studied were all considered clinically fit for surgery under spinal anaesthetic by the anaesthetist, who would administer the spinal anaesthetic.

Verbal informed consent was obtained from each subject after ensuring that the patient was fully aware of the research procedure. The protocol was approved and cleared by the Human Subjects Committee of the University of the Witwatersrand (Clearance number: 29/2/1991).

3.2 **Equipment used**

The Schiller Spirovitt - Switzerland SP-200 was used for all lung function testing. It was calibrated according to specifications of the machine manual. This machine was on loan from the Anaesthetic department, Johannesburg Hospital.

The investigator chose equipment that meets the minimum internationally accepted performance standards such as those recommended by the American Thoracic Society. (See Appendix E)

The Urology ward's bathroom scale was used to weigh all the patients. It had been calibrated. A wall height scale was made for the ward so that each patient's height could be obtained accurately in metres.

3.3 **Method**

All patients were admitted to the hospital the day before the T.U.R.P. surgery. A brief history was taken from the patient's file and a subjective examination was performed during the afternoon of the admission day. A brief data sheet was completed (see Appendix A) for each patient with special reference to the following:-

- age, weight and height;
- medical and surgical history;
- present medical condition;
- smoking habits;
- present medication.

The patient was then weighed and measured (height). The procedure for the lung function testing was explained and demonstrated to the patient. It is essential that the procedure be standardised and performed consistently in the same manner.

1. A period of quiet breathing is maintained until a constant tidal volume is reached for three consecutive breaths.

2. The subject is then instructed to exhale slowly and maximally.

3. When expiration is maximal (i.e. when residual volume has been reached), the subject is told to inhale as fast and as deeply as possible to total lung capacity and to hold the inspiration for 1-2 seconds.

4. Then to exhale as rapidly, forcefully and completely as possible.

5. A minimum of three acceptable FVC manoeuvres must be obtained (i.e. unhesitating start, smooth continuous expiration, absence of a cough, glottis closure, second inspiration, a leak and must have a complete expiration).

In this way the FVC, FEV_1, FEF and PEF were measured. Subjects unfamiliar with the technique practised in the sitting position before the study began until consistent values were obtained. Three readings were taken for each position. The best reading was recorded and then printed (Appendix B).

The test was performed in each of the following positions:-

Day prior to surgery -

a) with the patient sitting over the edge of a bed unsupported;

b) immediately after the patient had settled into a supine position;

c) after the patient had been in supine lying for ten minutes.

Day of surgery -

a) supine lying in the theatre just prior to the spinal anaesthetic;

b) supine lying following the spinal anaesthesia after the desired sensory/motor effect had been achieved (the fixation time).

The patients were instructed by the author to remain lying down for the period of twenty four hours.

Day one after surgery (approx. 24 hrs later) -

a) supine lying after the patient had been lying horizontal for approximately 24 hours;

b) immediately after the transition from supine lying to the sitting position with the patient's legs over the edge of the bed (unsupported);

c) after the patient had been sitting on the edge of the bed for ten minutes.

A total of eight readings were recorded and printed for each patient. A control group was deemed unnecessary as the patients acted as their own control before and after the anaesthetic.

3.4 Spinal anaesthesia

On the day of surgery baseline (prespinal) respiratory measurements were recorded in the pre-operative holding area in theatre less than one hour before the operation. These were measured in supine lying.

Spinal anaesthesia was administered in the operating room using the standard technique, in the sitting position, using a 22 gauge spinal needle. After identification of the subarachnoid space in the L 2/3 joint space, 2% Lidocaine was used to produce local anaesthesia of the skin and subcutaneous tissue. 0.5% Bupivicaine mixed with 50% Dextrose water was used for the spinal anaesthetic. The subject was then positioned in a 15 degree head down tilt position to facilitate the correct spread of the drug. Onset of the anaesthetic is fairly rapid following the subarachnoid injection (10 - 15 minutes).

The level of sensory anaesthesia to pinprick was assessed every five minutes. The patients noticed at onset a feeling of warmth and subsequently had no sensory perception of needle pricks to the thigh, tickling of the soles of the feet, strong punching, and pulling of pubic hairs. On stabilisation a motor and sensory level was determined. When the level was unchanged on two successive determinations, spirometry was repeated.

3.5 The operation

No sedative drugs were used in conjunction with the spinal anaesthetic. The patients' operations were all performed in the lithotomy position. The patients were held in the recovery room until considered fit for discharge to their general ward, where they remained in bed for the ensuing 24 hours.

3.6 Statistical analysis

Statistical analysis was carried out using the SAS Statistical software package.

The concept of probability (p) is the basis of all tests of statistical significance. When comparing the results of 2 sets of observations one assumes there is no difference between the data (the Null Hypothesis). A value of $p < 0.05$ was accepted in this research report as being significant, and if this level is reached then there is only 1 in 20 chance of the difference being due to accident alone.

While data mostly involves comparisons of results between 2 groups, at times analysis of results of more than 2 groups may be required, i.e. when one divides up a large group into its component parts. Multiple 2 sample t-tests between each pair of groups is a flawed

technique since it does not take into account associations in multiple comparisons and increases the chance of obtaining misleading results. The initial p value of 0.05 being a 5% error for each individual pair of comparisons, progressively increases with each additional paired test.

The Bonferroni t-test states that K number of tests are performed, each with a significant level of p, the probability of one or more significant tests occurring by chance alone would then be Kp. The resultant probability level should then be less than the desired p value, to be significant. In other words, each test result would only be considered to be truly significant if the calculated p divided by the K value, is equal to or less than the chosen p value of significance.

Analysis of variance (ANOVA) takes full account of these multiple comparisons. It allows for the analysis of the way in which the mean value of a variable is influenced by the classification of data. It also allows the sampling variations and testing variation to be separated and the magnitude estimated. The method of assessing how much of the overall variation in data is attributable to differences between the group mean, comparing this with the amount attributed to the difference between individuals in the same group. The technique uses the F ratio, i.e. the ratio of the variances of each group. The variance is the square of the Standard Deviations and equals the sum of the square deviations about the overall mean, divided by the degree of freedom.

The procedure followed was to first perform an analysis of variance (ANOVA), and then, if significant, multiple means tests (Bonferroni) to detect statistically significant differences between groups.

In some instances, where data was detected as unbalanced, i.e. missing values or unreasonable values. In these cases, the General Linear Models Procedure was used to perform analysis of variance.

The details of the package used were as follows:

- SAS/STAT software for Personal Computers, Release 6.03 (SAS Institute Inc., Carey, NC, USA).

- General Linear Models Procedure (Proc GLM) was used to perform analysis of variance for data that was unbalanced.

CHAPTER FOUR

RESULTS

Twenty five patients were assessed pre-operatively. A total of five patients were further excluded from the study for various reasons. These included three patients needing further investigations prior to surgery. One patient needed a general anaesthetic during surgery due to failure of the spinal anaesthesia, and one patient would not agree to a spinal anaesthesia at the time of surgery.

The characteristics of the remaining twenty patients who completed the study are given in Table 4.1. The range of ages of the patients was 65 - 86 years of ages (median = 73 years). The range of weight of the patients was 50-110 kilograms (20% = non obese, 35% = grade 1 obesity, 30% = grade 2 obesity, 15% = grade 3 obesity). The range of height of the patients was 1.50 m - 1.82 m (mean 1.67 metres). Patients who had given up smoking in the six weeks prior to surgery were classified as smokers. Seventy five percent of the patients smoked.

The duration of surgery varied between 35 minutes and 120 minutes. All patients tolerated the procedure well. No additional intradural analgesia or sedation of any kind was required by the remaining twenty patients during or after the operation. All patients remained in supine for approximately twenty four hours post operatively.

Patient Number	Age	Obese	Smoker	Medical History	Needle Level	Sensory Level
1	73	II	Yes	COPD	L2/3	T9/10
2	70	III	No	Hypertensi	L2/3	T9/10
3	67	II	Yes	(L) CVA	L2/3	T9/10
4	65	I	No	Nil	L2/3	T11/12
5	86	II	No	Nil	L3/4	T10/11
6	73	I	Yes	Nil	L3/4	T9/10
7	71	II	Yes	(L) CVA	L2/3	T11/12
8	71	III	No	Angina	L2/3	T11/12
9	80	0	Yes	COPD	L2/3	T8/9
10	79	0	Yes	COPD	L3/4	T9/10
11	73	I	Yes	COPD	L2/3	T8/9
12	82	II	Yes	COPD	L3/4	T9/10
13	69	I	Yes	COPD	L2/3	T9/10
14	79	0	Yes	COPD	L2/3	T9/10
15	81	I	Yes	COPD	L2/3	T7/8
16	68	II	Yes	COPD	L3/4	T8/9
17	83	0	Yes	COPD	L1/2	T9/10
18	82	I	Yes	COPD	L2/3	T9/10
19	78	I	No	Nil	L2/3	T10/11
20	68	III	Yes	COPD	L2/3	T10/11

TABLE 4.1 Demographic Data of Patients

Obese = Body Mass Index (See Appendix)
L = Lumbar Vertebral Space
T = Thoracic Vertebral Space
COPD = Chronic Obstructive Pulmonary Disease
CVA = Cerebral Vascular Accident
(L) = Left

Obesity was measured according to the Body Mass index and graded accordingly. Eighty four percent of the patients were considered to be obese (see Table 4.1). The relevant medical history taken from the anaesthetist's assessment form of each patient revealed that sixty percent of the patients had chronic obstructive pulmonary disease. All patients that were classified as having COPD were smokers. Of all the smokers, 3 patients were not clinically assessed to have COPD. Only 4 of the COPD patients were not obese but they were all smokers.

Results of the lung function testing:

It became clear on analysing the statistics of this study that posture and little else played the major role in causing changes in pulmonary function and little else. In order to make comparisons to enable us to see if any other trends became evident, the results were grouped and analysed in three different ways. The four parameters in lung function testing FVC, FEV_1, FEF and PEF were analysed separately in the following manner:

1. The results were grouped together, taking the time period only into consideration, i.e. pre-operatively, day of the operation and post-operatively.

2. The results were grouped together, taking the posture into consideration, i.e. supine, sitting and a third group of the patients in supine under the effects of spinal anaesthesia.

3. The results were analysed using the 8 different position (Page 46).

Abbreviated key to clarify the following tables:

Position 1 = Sitting	}	
Position 2 = Lying	}	Pre-operative
Position 3 = Lying - 10 minutes	}	
Position 4 = Lying - pre anaesthesia	}	Day of operation
Position 5 = Lying and blocked - post anaesthesia	}	pre-surgery
Position 6 = Lying after 24 hours	}	
Position 7 = Sitting	}	post-operative
Position 8 = Sitting - 10 minutes	}	

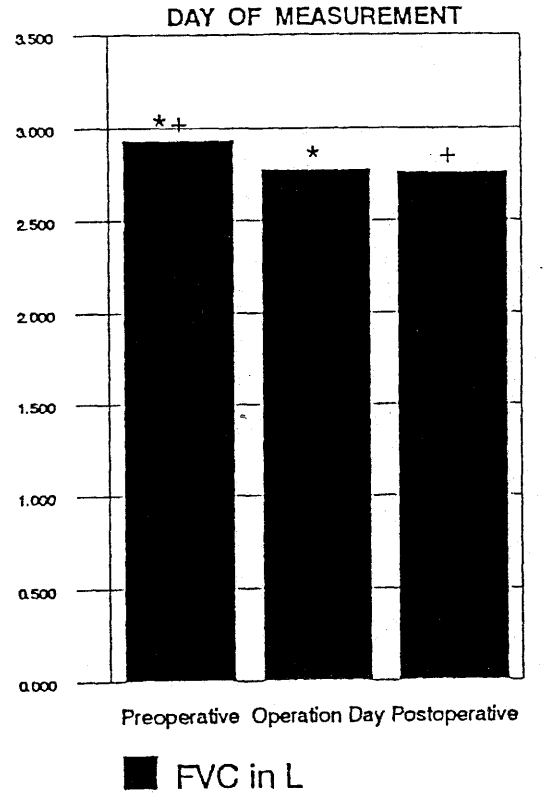
Forced Vital Capacity

Level of Time	N **	Mean (L)	SD
Pre-Op	59	2.933	1.054
Op	38	2.775	0.944
Post-Op	60	2.760	1.017

Table 4.2 F.V.C. : Effects of the day of measurement $p < 0.05$

** Skewed data - see statistical analysis

The pre-operative FVC value is the highest and the post-operative FVC value the lowest. The pre-operative value significantly differs from the value on the day of the operation* and the pre-operative value significantly differs from the post-operative value+ ($p < 0.05$). See figure 4.1.



Mean and SD as in table 4.2

Figure 4.1

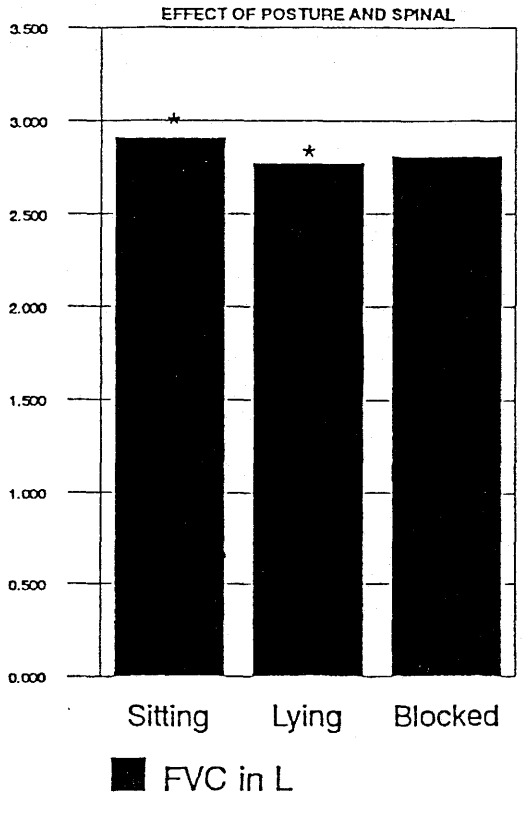
Forced Vital Capacity

Level of Posture	N **	Mean (L)	SD
Sitting	59	2.911	1.073
Lying	79	2.772	0.987
Blocked	19	2.808	0.944

Table 4.3 F.V.C. : Effects of posture and the spinal anaesthetic

$p < 0.05$ ** Skewed data - see statistical analysis

The highest FVC value is in sitting and the lowest FVC value is in the lying position. There is a significant difference between sitting and lying values* ($p < 0.05$). See figure 4.2.



Mean and SD as in table 4.3

Figure 4.2

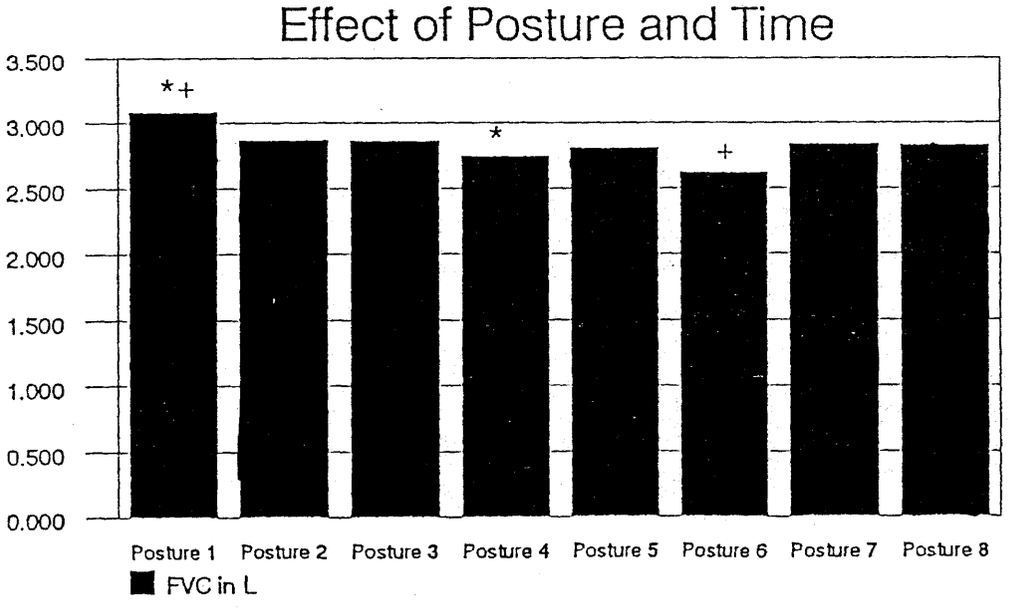


Figure 4.3

Mean and SD as in table .4.4

* Differ significantly from each other

+ Differ significantly from each other

Level of Posture	N **	Mean (L)	SD
Sitting 1	19	3.078	1.187
Lying 2	20	2.866	0.975
Lying 3	20	2.862	1.037
Lying 4	19	2.742	0.969
Blocked	19	2.808	0.944
Lying 6	20	2.617	1.020
Sitting 7	20	2.838	1.013
Sitting 8	20	2.826	1.054

Table 4.4 F.V.C. : Effects of different postures and time of readings

(See Appendix D) $p < 0.05$

** Skewed data - see statistical analysis

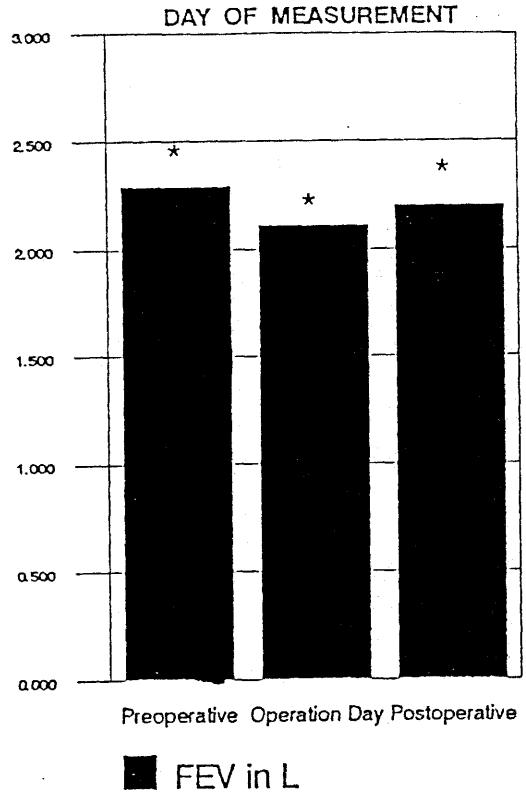
The highest FVC value is the Sitting 1 position. As seen in the table, the FVC value decreases gradually. As the patient starts mobilising post operatively which is indicated in Sitting 7 and 8 positions, the values then increase slightly. Lying 4 position value significantly differs from Sitting 1 value* and the value in Lying 6 differs significantly from the value in Sitting 1 position+ ($p < 0.05$). See figure 4.3, opposite page.

Forced Expiratory Volume$_1$

Level of Time	N	Mean (L)	SD
Pre-Op	60	2.29	0.992
Op	40	2.11	0.907
Post-Op	60	2.20	1.086

Table 4.5 FEV_1 : Effects of the day of measurement $p < 0.05$

The pre-operative FEV_1 value is the highest and the FEV_1 values taken on the day of operation has the lowest value. All three readings are significantly different from each other* ($p < 0.05$). See figure 4.4.



Mean and SD as in table 4.5

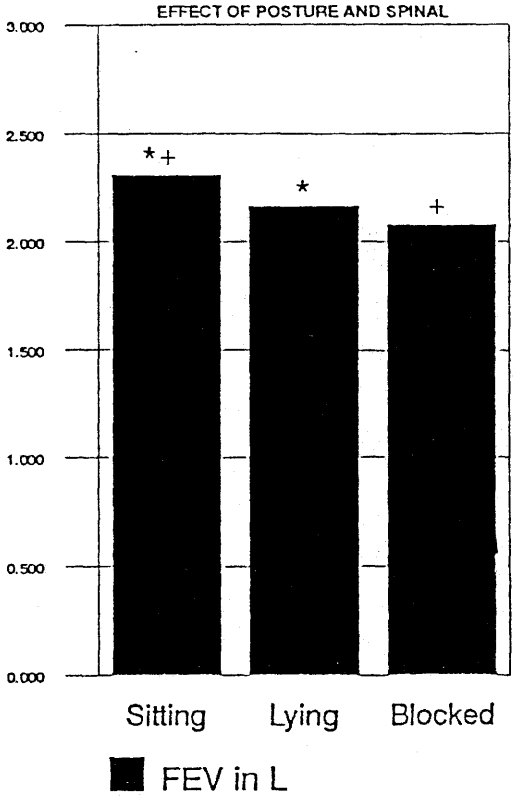
Figure 4.4

Forced Expiratory Volume$_1$

Level of Posture	N	Mean (L)	SD
Sitting	60	2.311	1.067
Lying	80	2.167	0.985
Blocked	20	2.078	0.903

Table 4.6 FEV_1 : Effects of posture and the spinal anaesthesia ($p < 0.05$)

The sitting position has the highest FEV_1 value while the spinal anaesthesia (blocked) FEV_1 value is the lowest. The sitting and lying readings differ significantly from each other* and the sitting and blocked values differ significantly from each other+ ($p < 0.05$). See figure 4.5.



Mean and SD as in table 4.6

Figure 4.5

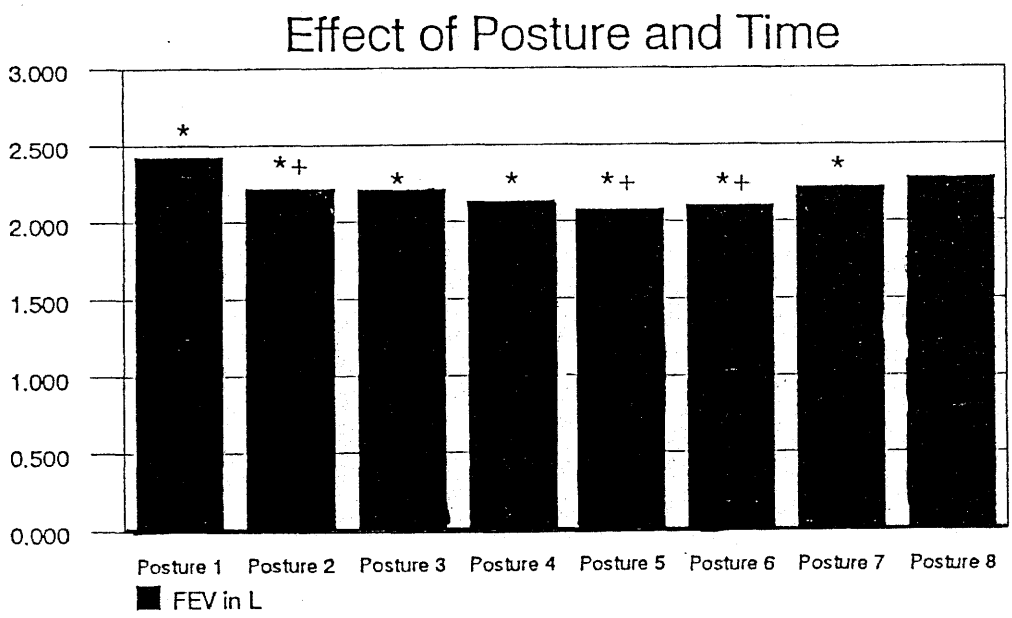


Figure 4.6

Mean and SD as in table 4.7

* Sitting 1 differs significantly from positions 2,3,4,5,6,7.

\+ Posture 2 differs significantly from positions 5,6.

Level of Posture	N	Mean (L)	SD
Sitting 1	20	2.428	1.018
Lying 2	20	2.218	0.935
Lying 3	20	2.211	1.055
Lying 4	20	2.134	0.934
Blocked	20	2.078	0.903
Lying 6	20	2.104	1.080
Sitting 7	20	2.225	1.069
Sitting 8	20	2.281	1.157

Table 4.7 FEV_1 : Effects of different postures and time of readings (See Appendix D) $p < 0.05$

The Sitting 1 position has the highest FEV_1 value. This value decreases gradually until the Blocked 5 value which is the lowest. The FEV_1 values gradually increase from the Position 5 to the Position 8 which is taken in the Sitting position. The Sitting 8 position has the second highest FEV_1 value of all. Sitting 1 value significantly differs from Lying 2; Lying 3; Lying 4; Blocked 5; Lying 6; and Sitting 7 values ($p < 0.05$).

Lying 2 value significantly differs from Blocked 5; and Lying 6 values ($p < 0.05$) See figure 4.6, opposite page.

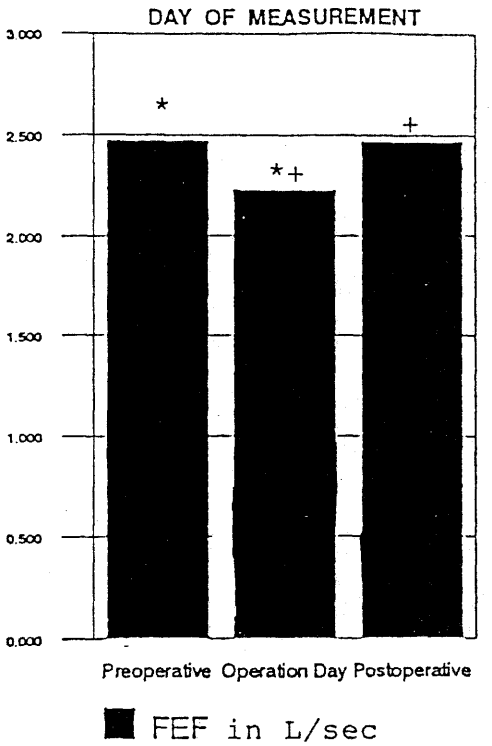
Forced Expiratory Flow

Level of Time	N **	Mean (L/sec)	SD
Pre-Op	60	2.474	1.814
Op	40	2.227	1.395
Post-Op	59	2.470	1.669

Table 4.8 FEF : Effects of the day of measurement $p < 0.05$

** Skewed data - see statistical analysis

The pre-operative FEF value is the highest and the FEF values taken on the day of the operation the lowest. The pre-operative value and the values recorded on the day of the operation significantly differ from each other*, and the post-operative value significantly differs from the value recorded on the day of operation+ ($p < 0.05$). See figure 4.7.



Mean and SD as in table 4.8

Figure 4.7

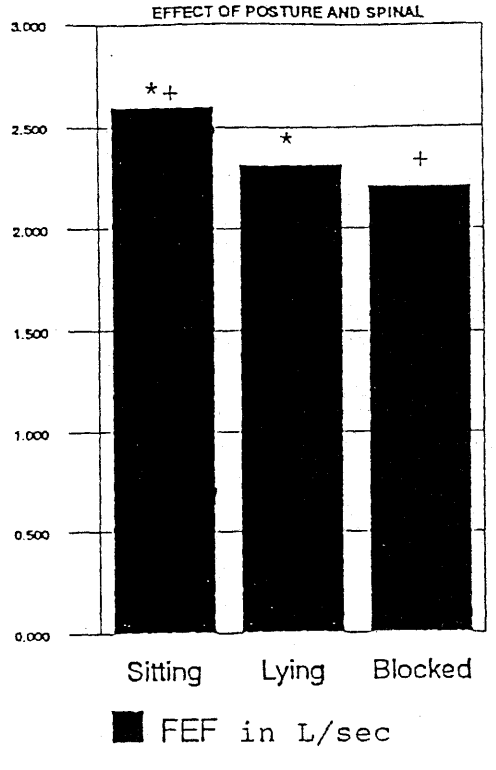
Forced Expiratory Flow

Level of Posture	N **	Mean (L/sec)	SD
Sitting	60	2.599	1.786
Lying	79	2.315	1.622
Blocked	20	2.210	1.385

Table 4.9 FEF : Effects of posture and the spinal anaesthetic

$p < 0.05$ ** Skewed data - see statistical analysis

The sitting FEF value is the highest while the value taken after the spinal anaesthesia (blocked) is the lowest. The sitting and lying FEF values differ significantly from each other* and the sitting and blocked values differ significantly from each other+ ($p < 0.05$). See figure 4.8.



Mean and SD as in table 4.9

Figure 4.8

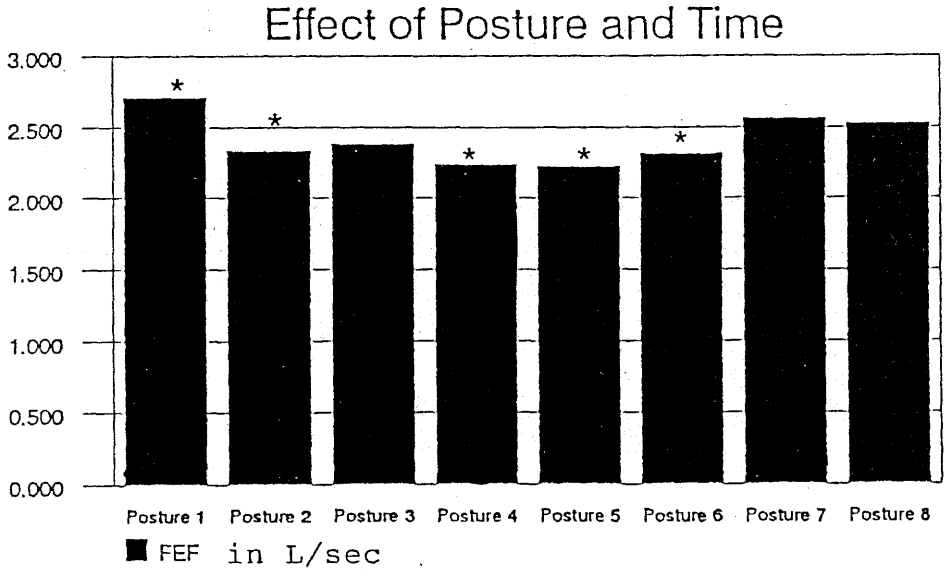


Figure 4.9

Mean and SD as in table 4.10

* Position 1 differs significantly from positions 2,4,5,6.

Level of Posture	N **	Mean (L/sec)	SD
Sitting 1	20	2.710	1.922
Lying 2	20	2.330	1.696
Lying 3	20	2.382	1.887
Lying 4	20	2.234	1.442
Blocked	20	2.221	1.385
Lying 6	19	2.314	1.550
Sitting 7	20	2.562	1.742
Sitting 8	20	2.527	1.776

Table 4.10 FEF : Effects of different postures and time of readings

(See Appendix D) $p < 0.05$ ** Skewed data - see statistical analysis

The Sitting 1 position has the highest FEF value and thereafter the values decrease gradually until the Blocked 5 position value which is the lowest. The value the increases as the patient starts mobilising which is indicated by the values recorded in the sitting positions.

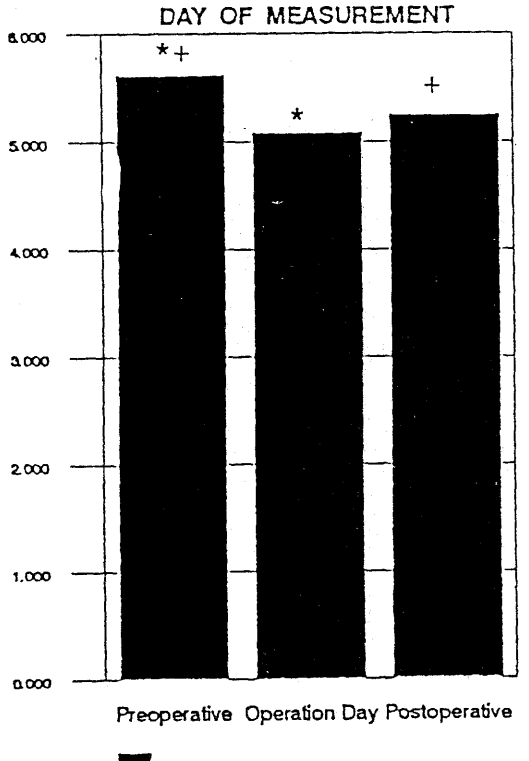
Lying 2; Lying 4; Blocked 5; and Lying 6 values significantly differ from the Sitting 1 value* ($p < 0.05$). See figure 4.9, opposite page.

Peak Expiratory Flow

Level of Time	N	Mean (L/sec)	SD
Pre-Op	60	5.614	2.867
Op	40	5.085	2.672
Post-Op	60	5.249	2.777

Table 4.11 PEF : Effects of the day of measurement $p < 0.05$

The pre-operative PEF value is the highest and the values taken on the day of operation the lowest. The values of the PEF as determined pre-operatively and on the day of the operation significantly differ from each other*, and the post-operative PEF value and value on the pre-operative day significantly differ from each other+ ($p < 0.05$). See figure 4.10.



Mean and SD as in table 4.11

Figure 4.10

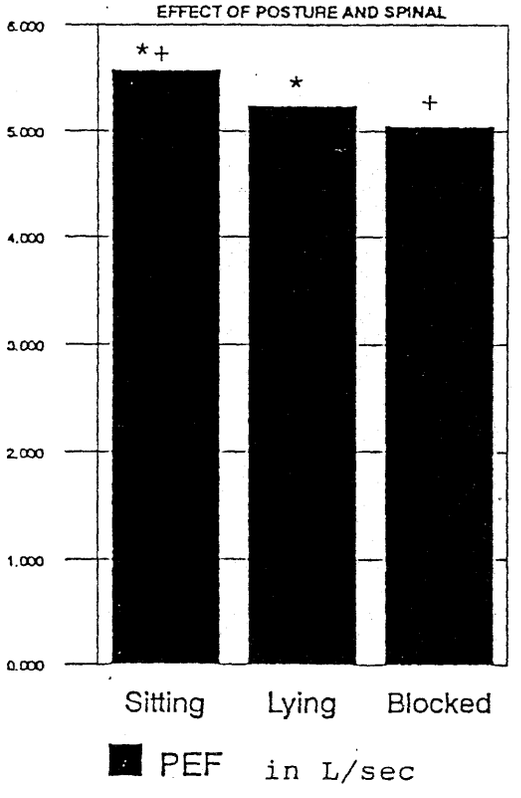
Peak Expiratory Flow

Level of Posture	N	Mean (L/sec)	SD
Sitting	60	5.580	2.797
Lying	80	5.242	2.795
Blocked	20	5.051	2.732

Table 4.12 PEF : Effects of posture and the spinal anaesthetic

$p < 0.05$

The PEF value in the Sitting position is the highest while the value after the spinal anaesthesia (blocked) is the lowest. The values taken in the Sitting and Lying positions differ significantly from each other* and the sitting and blocked values differ significantly from each other+. ($p < 0.05$). See figure 4.11.



Mean and SD as in table 4.12

Figure 4.11

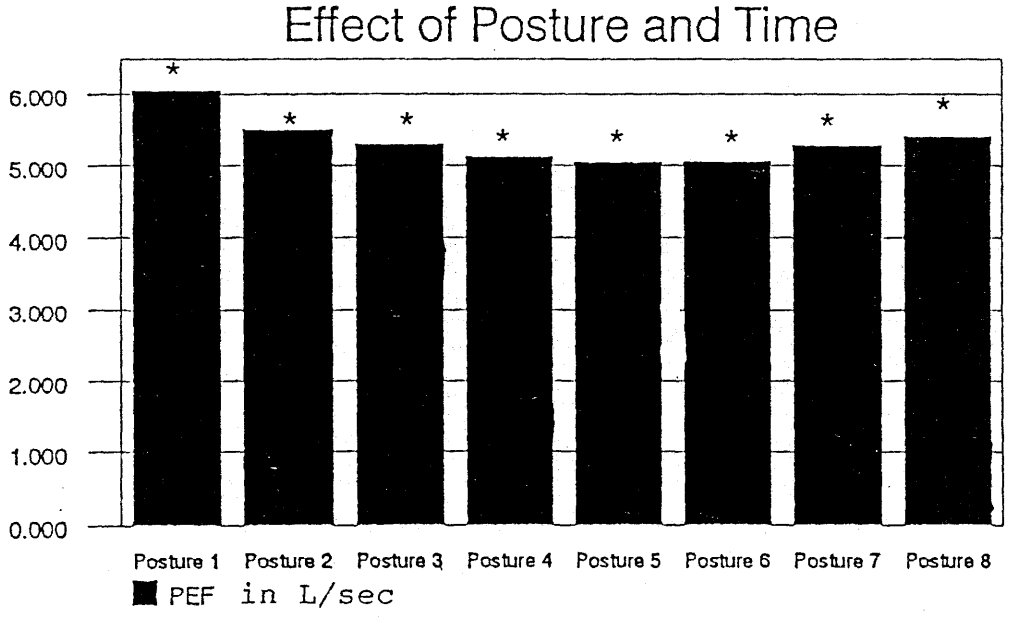


Figure 4.12

Mean and SD as in table 4.13

* Position 1 differs significantly to all other values.

Level of Posture	N	Mean (L/sec)	SD
Sitting 1	20	6.052	2.832
Lying 2	20	5.499	2.826
Lying 3	20	5.292	3.033
Lying 4	20	5.120	2.681
Blocked	20	5.051	2.732
Lying 6	20	5.058	2.824
Sitting 7	20	5.282	2.727
Sitting 8	20	5.407	2.912

Table 4.13 PEF : Effects of different postures and time of readings

(See Appendix D) $p < 0.05$

The PEF value in the Sitting 1 position has the highest reading. The values of the other positions decrease gradually until the Blocked 5 position which is the lowest. The values then increase gradually as the patient mobilises which is indicated by the values recorded in the Sitting positions. The Sitting 1 position value differs significantly from all the other values* ($p < 0.05$). See figure 4.12, opposite page.

CHAPTER 5

DISCUSSION

The sample of patients in this study as seen in Table 4.1 were all over the age of 65. The structural component most affected by age in the respiratory system is the pulmonary elasticity. With advancing age, lung elastic content decreases and the fibrous connective tissue increases proportionately. An inevitable and progressive loss of lung elastic recoil results. Although this results in making the aging lung more compliant, it reduces the ability to maintain the small airway patency [40].

The decrease in the ventilatory capacity with aging may further be affected by smoking. The impairment due to smoking is related to the daily consumption of tobacco, the period of smoking, whether inhalation occurs and the extent to which smoking predisposes the subject to a productive cough and episodes of bronchial infections. In Johannesburg, a major industrial area, there is such widespread air pollution that even non-smokers can be predisposed towards lung complaints.

Smoke is composed of a number of substances that affect the lungs, in particular, oxides of sulphur and nitrogen, all of which are irritants to the bronchial epithelium. These substances cause goblet cell destruction, alveolar septal rupture, thickening of bronchial epithelium and mucous gland hypertrophy and thus causes chronic obstructive pulmonary disease

(COPD). Sixty percent of the patients in the study were diagnosed as having COPD, and all of these patients were classified as smokers. Only 4 of these patients were not obese. From a physiotherapists perspective, these factors place all these patients in this study in a high risk group. Only 4 out of the 20 patients had ceased smoking in the week prior to surgery to minimise post-operative complications. All these patients were COPD patients with non-infected productive coughs.

As had already been discussed, lung volumes vary amongst healthy persons, according to age, sex and physical structures. These values will vary further according to the pulmonary status.

Fortunately, the important dynamic properties of the respiratory system can be assessed by several readily available tests of airway function. The most widely used is the forced expiratory volume in one second (FEV_1). Others include FVC, $FEF_{25-75\%}$, and PEF. None of these has any particular advantage over FEV_1, except that $FEF_{25-75\%}$ is less dependent on the effort exerted by the subject than the other variables and reflects the flow properties of small as well as large airways.

Most of the literature used the parameter of FRC as a point of discussion[1,5,18,29,30,35,39]. This value can only be measured using dilution or washout of an inert gas or whole body plesthysmography. As these tests are not easily done in the wards, this value is seldom available for use as assessment of the patient prior or after surgery. Therefore this parameter has not been used in this study at all.

Although all results of this study did show some significant difference this was only on specific statistical testing. There was no statistical significance in the paired t-Tests. This may be due to the fact that the numbers in the study were small, especially in the "blocked" group where there was only a total of 20 values.

Effects of the operation

These results were compared to show a general trend of the patient's pulmonary function from the pre-operative day to the post-operative day. Excepting for the results of FVC, the parameters FEV_1, $FEF_{25-75\%}$, and PEF all show that the values of these lung function parameters decrease pre-operatively to those values recorded on the day of the operation. The values increase again post-operatively although to not as high as the pre-operative lung function values. The FVC value continued to decrease from operation day, post-operatively.

It is to be expected that lung functions would be at their lowest on the day of the operation because the patient is in supine lying and has had a spinal anaesthesia and has therefore been fairly immobile. Post-operatively the patient would be sitting up and moving around in bed and the mobility would increase the demand for larger pulmonary volumes and therefore improve the pulmonary function values.

Possible reasons for the FVC to decrease post-operatively is the fact that COPD patients usually have excessive pulmonary secretions. The

secretions accumulate causing a decrease in pulmonary volume and therefore a decreased FVC [12].

Effects of posture

The results of the test investigating the effects of posture on lung functions are supported by the literature[27,28,37,38]. There were, in all the pulmonary function parameters, significant decreases in values between sitting and the supine positions.

Vellody[39] concludes in his study that in the sitting posture, effective muscle action is being applied to move the rib cage which does not appear to be applied in the supine position. The inspiratory muscles involved are the neck and rib cage muscles and the diaphragm. For the diaphragm to move the rib cage, the diaphragmatic dome must be stabilised so minimal downward movement with contraction occurs. In the sitting leaning forward position the thorax is stabilised by the upper limbs.

In the case of obese patients, as in this study, the cephalad movement of the diaphragm in the supine position will further contribute to decreased pulmonary volumes as the abdominal viscera is displaced upwards[30]. In this study there was no significant difference in the change in lung functions, comparing the non-obese and grade 1 obesity patients with those patients that were more significantly obese, i.e. grade 2 and 3 obesity patients. Owing to the small sample size of this study, these results cannot be conclusive.

All theories that have been postulated are clearly of clinical significance in their own way and no one theory can be more correct than the others. I feel therefore that it is a combination of all these factors that causes a decrease in pulmonary function as a patient moves from the sitting to the supine position.

The results of the effects of spinal anaesthetic on pulmonary function are examined and FEV_1, FEF and PEF are significantly different from the sitting results but not from the lying results. In the FVC table, 4.6, the spinal anaesthetic value increases very slightly from the value in the lying position, but not significantly. Possibly if the spinal anaesthetic level was higher, i.e. involving more respiratory muscles, this increase would be more significant as the expiratory effort would need to be far greater to achieve the same pulmonary function values.

In a review article of respiratory effects of spinal anaesthesia Steinbrook[17] 1989 states that resting ventilation is not substantially altered by spinal anaesthesia. Spinal anaesthesia has no clinically significant effect on tidal volume, respiratory rate, minute ventilation, or arterial blood gas tensions.

Effects of posture and time

Taking each different position into account, it is interesting to note that Sitting 1 position is the highest value of all 8 positions. Even after the patient has been sitting for ten minutes in Sitting 8 position the value has not yet returned to the pre-operative sitting value. Although these results

may not be clinically significant they show a definite trend of being:

a) mostly affected by posture;

b) minimally affected by spinal anaesthesia; and

c) affected by being supine for approximately 24 hours..

In the PEF set of values Sitting 1 position differs significantly to all other results even to Sitting 8 position. Clinically this result is important as the maximum expiratory flow a patient can achieve will determine the effectiveness of the cough. As 60% of the patients in this study have COPD and all are of an age that their pulmonary functions are decreased, the ability to cough is important to clear any pulmonary secretions and therefore prevent post-operative pulmonary complications. If these secretions remain in the lungs they will contribute to closure of airways, development of atelectasis and decreased ventilation 7. This becomes a matter of concern post-operatively especially to the physiotherapist.

These factors decrease pulmonary compliance and hence reduce the ability of the lungs to expand, and therefore would show a decrease in the FVC results. In figure 4.1 post-operatively the FVC is lower than both other results and in figure 4.3 there is a fairly steady decrease in the FVC and even with mobilising into sitting post-operatively. Although the values improve they remain lower than all the readings on the pre-operative day.

The results of FEV or $FEF_{25-75\%}$, as discussed, are fairly independent of expiratory effort as they show more of a trend in that they decrease with positional change and not from the build up of secretions post operatively, or from the spinal anaesthesia. The spinal anaesthesia does not seem to

cause too much of a significant change between the values recorded in the Lying 4, Blocked 5 and Lying 6 positions. This would be in agreement with the literature as discussed in the previous section [17].

In this study we tested pulmonary functions of patients following change in postures, i.e. from sitting to supine lying and vice versa. We included testing these patients in a position and again after that specific position had been maintained for ten minutes. I was interested to see if there was any significant decrease or increase in the results after the ten minute period when the position had remained static. The changes in lung volumes with posture have been assumed to persist while the position is maintained. If one studies the results of this study, it can be seen that there are further slight changes but they are not statistically significant and definitely not clinically significant. These results would support the literature although data also suggested that prolonged bedrest did cause a gradual process independent of muscular force or strength.

This study shows that lung functions improve with the change in posture from supine to sitting. The improvement shown in the study supports the physiotherapy regimen of early mobilisation for post-operative patients to minimise the risk of post-operative complications. However, as seen from the results merely sitting the patient is not sufficient to restore the values to the pre-operative sitting values.

It would appear then that an additional treatment modality is evident for complete restoration of lung functions. Jenkins et al[15] compared early mobilisation and instruction in coughing and huffing with a programme

that included that already mentioned with incentive spirometry and breathing exercises. A total of 131 male patients were assessed post operatively for 5 days. No significant difference was found between the groups at the start of the study or at any time during the operation. Neither treatment programme was superior in restoring lung functions or in preventing chest infections.

If, as seen in the author's study, minimal mobilisation (i.e. sitting) restores pulmonary function to a large extent, then it is possible that if physiotherapists and the ward staff aim for early ambulation, this may be of further benefit. This would need a more extensive, separate research study.

The period of twenty four hours of lying following a spinal anaesthesia is supposed to help reduce the incident of postdural headaches. The technique of using a small needle for the spinal anaesthesia reduces the incidence of the puncture headache [42].

It can be noted in the literature that the period of recumbency after spinal anaesthesia has not been found to decrease the incidence of the postdural puncture headache [42,43] and some data even indicates that early ambulation may actually decrease the incidence of this headache [44,45].

In this study there was no incidence of postdural headache. Possibly then it would be worth investigating whether mobilising the patient earlier, as soon as the full effects of the spinal anaesthesia has worn off, would lead to the patients' lung function returning to normal sooner. As the TURP

patients have minimal pain or discomfort mobility should not be a problem. I generally found the patients anxious to get out of bed sooner than the twenty four hour period.

The literature supports early mobility[30,31] and states that it is important to avoid the supine position in high risk patients, i.e. those patients that are older, overweight or who smoke and those whose pulmonary functions are decreased.

CONCLUSIONS

It should be noted that a relatively small number of subjects were examined in this study, therefore the statistical data can only indicate a trend in the effects of posture and spinal anaesthesia on lung functions.

In conclusion, in all four parameters (FEV, FVC, PEF and FEF) of the lung function tests, there were significant differences ($p < 0.05$) between the sitting and lying positions. The effects of the spinal anaesthesia were minimal. The results of the testing showed that even though patients had had a spinal anaesthesia and had been supine for at least 24 hours, lung functions returned to almost pre-operative levels, post-operatively just by getting the patient sitting.

All day, everyday, the position of a patient influences his lung function. Using this to our advantage requires no great technical skill, just common sense.

LIMITATIONS

I am aware that the patients willingness and ability to co-operate were essential in the execution of the lung function tests. Although an attempt was made to gain co-operation in every instance, optimal conditions were not always possible. All tests were conducted in the ward according to routine procedure.

Although, acknowledging that I studied a relatively small population sample I can say that posture may be considered an aggravating factor, predisposing to respiratory complications in surgical patients operated on under spinal anaesthesia and who remained supine for a further 24 hours.

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APPENDIX

APPENDIX A

SPINAL ANAESTHESIA RESEARCH

NUMBER

NAME :.....

AGE :.....

DATE OF ASSESSMENT :.....

HEIGHT :.....cms

WEIGHT :.....kgs

TYPE OF OPERATION :.....

DATE OF OPERATION :.....

SURGICAL HISTORY :.....

.....

.....

.....

MEDICAL HISTORY :.....

.....

.....

.....

SMOKERS Yes/No If No, PREVIOUS SMOKER Yes/No

PRESENT MEDICATION :.....

ANAESTHETIST :.....

LEVEL OF ANAESTHETIC :.....

SENSORY LEVEL OBTAINED :.....

LENGTH OF SURGERY :.....

SURGICAL COMPLICATIONS :.....

.....

.....

.....

MEDICATION, IF ANY, GIVEN DURING SURGERY :.....

.....

.....

APPENDIX B

Body Mass Index

Obesity = Weight/Height^2

Obesity = Grade I = 20 - 24.9 kg/c m^2
Grade II = 25 - 29.9 kg/cm^2
Grade III = 30 - 40.0 kg/cm^2
Grade IV = > 40 kg/cm^2

Pat-Name:

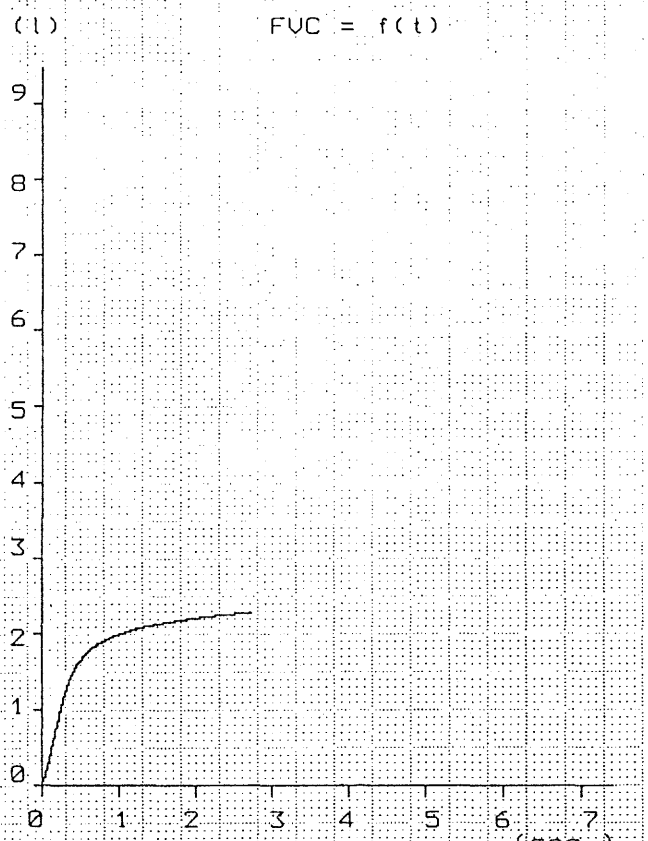
Pat-No:
1129001
Born: 24-11-20
Age: 71 years
Sex: M
Height: 159 cm
Weight: 76 kg

Norm values: ECCS/QUANJER

	MEAS.	PRED.	%PRED.
FVC	2.29 l	2.96 l	77 %
FEV0.5	1.65 l	–	–
FEV1.0	2.00 l	2.29 l	87 %
FEV3.0	–	–	–
FEV0.5/FVC	71.9 %	–	–
FEV1.0/FVC	87.4 %	74.5 %	117 %
FEV3.0/FVC	–	–	–
FEF.2-1.2	4.35 l/s	–	–
FEF25-75%	2.85 l/s	2.74 l/s	104 %
FEF75-85%	0.74 l/s	–	–
PEF	4.80 l/s	6.87 l/s	70 %
MEF75%	4.31 l/s	6.15 l/s	70 %
MEF50%	3.66 l/s	3.48 l/s	105 %
MEF25%	1.16 l/s	0.96 l/s	121 %

DIAGNOSIS: RESTRICTIVE

CLINTON PFTS (SURGERY)
Th 30-JAN-92 08:02:00 2.0 5



APPENDIX C

APPENDIX D

Postures in which tests were conducted.

Day Prior to Surgery -

Sitting 1 = with the patient sitting over the edge of a bed unsupported;

Lying 2 = immediately after the patient had settled into a supine position;

Lying 3 = after the patient had been in supine lying for ten minutes.

Day of Surgery -

Lying 4 = supine lying in the theatre just prior to the spinal anaesthetic;

Blocked 5 = supine lying following the spinal anaesthesia after the desired sensory/motor effect had been achieved.

Day One After Surgery

Lying 6 = supine lying after the patient had been lying horizontal for approximately 24 hours;

Sitting 7 = immediately after the transition from supine lying to the sitting position with the patient's legs over the edge of the bed (unsupported);

Sitting 8 = after the patient had been sitting on the edge of the bed for ten minutes.

Table 11-1 Minimal spirometry standards*

Test	Range/accuracy BTPS (L)	Flow range (L/sec)	Time (sec)	Resistance/back pressure	Test signals
VC	7 L ± 3% or 50 ml, whichever is greater	0-12	30		3-L calibrated syringe
FVC	7 L ± 3% or 50 ml, whichever is greater	0-12	15		24 standard waveforms
FEV_T	7 L ± 3% or 50 ml, whichever is greater	0-12	T	Less than 1.5 cm H_2O/L/sec at 12.0 L/sec flow	24 standard waveforms
Time zero	Time point from which all FEV_T measurements are taken			Determined by back-extrapolation	
$FEF_{25\%-75\%}$	7 L ± 5% or 0.2 L/sec, whichever is greater	0-12	15	Same as FEV_T	24 standard waveforms
$\dot{V}$	12 L/sec ± 5% or 0.2 L/sec whichever is greater	0-12	15	Same as FEV_T	Manufacturer proof
MVV	Sine wave 250 L/min at 2-L tidal volume to ±5% of reading	0-12 ±5%	12-15 ±3%	Less than ±10 cm H_2O at 2 L V_T at 2.0 Hz	Sine wave pump 0.4 Hz ± 10% at 12 L/sec

*Summarized from Standardization of spirometry—1987 update, Am Rev Respir Dis 136:1285, 1987.